Unusual 'paddling' trails left by gulls and 'aviturbation' in Rarawa and Mangawhai Estuaries, Northland, New Zealand

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Abstract

New Zealand's common seashore gulls *Larus dominicanus* and *L. novaehollandiae scopulinus* sometimes feed on intertidal sandflats by 'foot-paddling' as they move progressively backwards. In so doing they momentarily liquefy sediment freeing the small animals upon which they feed. This may leave at the surface an unusual and distinctive meniscus-like trail sometimes reaching 20 cm in width and exceeding 3 metres in length. The depth of disturbance may reach 5 cm. This trail superficially resembles the large and enigmatic Late Cambrian trace fossil, *Climactichnites,* thought to have been produced by an animal moving across damp sand.

The size and extent of these *Larus* trails, suggests that herein lies a further mechanism which could effect contaminant transfer to some depth in intertidal sediments - perhaps one locally comparable in importance to burrowing invertebrates and bottom feeding fish such as eagle rays. 'Aviturbation' could also be of particular significance around estuaries and wetlands where flocks of shore birds, including migrants, congregate. There is also a remote possibility that the trails may be preserved as trace fossils. Claimed similarities of traces of this kind to the well-known ichnogenus *Rhizocorallium* have been overstated.

Keywords: Black-backed and Red-billed gulls - paddling trails - Rarawa estuary - bioturbation - contaminant transfer - *Rhizocorallium*-like

Introduction

Muddy-to-sandy intertidal flats of harbours and estuaries are important in the feeding ecology of many shore and migratory birds. Individual species may be identifiable from their footprints, walking trails and trackways or other distinctive spoor features (e.g. Jaeger 1948). However, when congregating and resting, their gentle trampling activities may so thoroughly disturb and mix surficial sediments, that identifiable traces are destroyed. The importance of this avian bioturbation ('aviturbation') in enhancing biogeochemical exchange across the sediment-water interface has had general recognition (Thiel 1981).

On the other hand, with the exception of Wadden Sea tidal flats, little attention has been paid to individual bird feeding traces in these environments (see Cadée 1990) although recently Thrush *et al.* (1994) have noted that shorebird predation has a significant impact on macrobenthic community structure of Manukau Harbour's intertidal sandflats.

Unusual Traces - Rarawa Estuary

At low tide, during a visit to Rarawa estuary

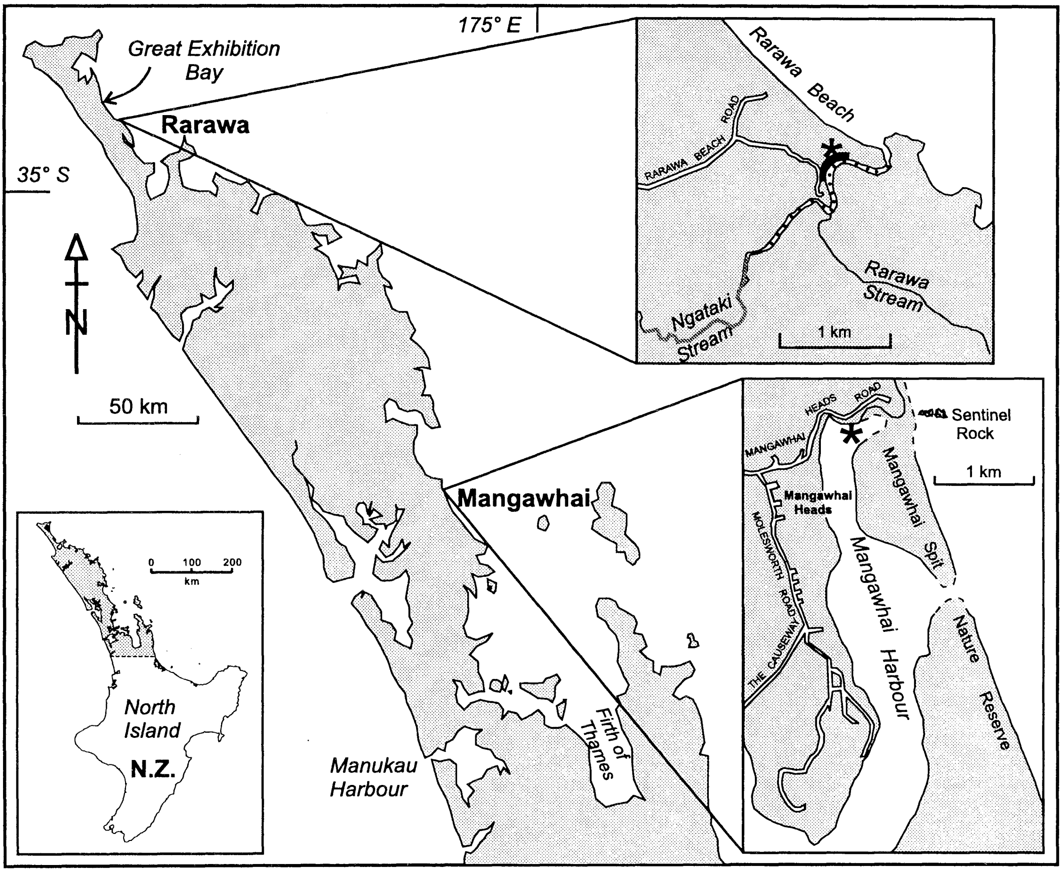

Figure 1 Location of Rarawa Estuary and tidal flat where the illustrated paddling trails were found; Mangawhai Estuary is also indicated.

(Fig. 1) in February 1994, a large number of two unusual traces (Figs. 2-4) were noted over an area of several hundred m^2. They spread from the low tide mark of the creek's bank (Fig. 2) across the flanking tidal flats to almost the wrack line of the last high tide (Fig. 4). It appeared that there was only one generation of conspicuous traces and that they had been left exposed on the ebbing tide. The surface of the intertidal-flat was locally rippled (Fig. 3a) and there were features suggesting degraded and erosional remnants of the traces may have persisted through more than one tidal cycle (e.g. Fig 2). Substrate sediments are non-consolidated, well sorted fine quartz sands with a modal size of 2.75-3.00 ϕ (Fig. 5), and which readily liquify upon agitation or gentle shaking. The redox boundary to dark grey or black, H_2S-smelling sediment was sharp and generally lay at a depth of <2 cm. A clearly defined, bright greenish horizon 1-2 mm thick, indicative of filamentous algae, bacteria and diatoms, was conspicuous within the uppermost centimetre across the sandflat.

Of the two types of trace recognised, one was a simple W-shaped impression, of rounded to squarish outline, 1-3 cm in depth and typically 15-20 cm across (Figs. 2a and b) and suggestive of a cloven hoof print. The other was a trail (Figs 3a and b) which frequently could be followed for distances of a metre or so and some-

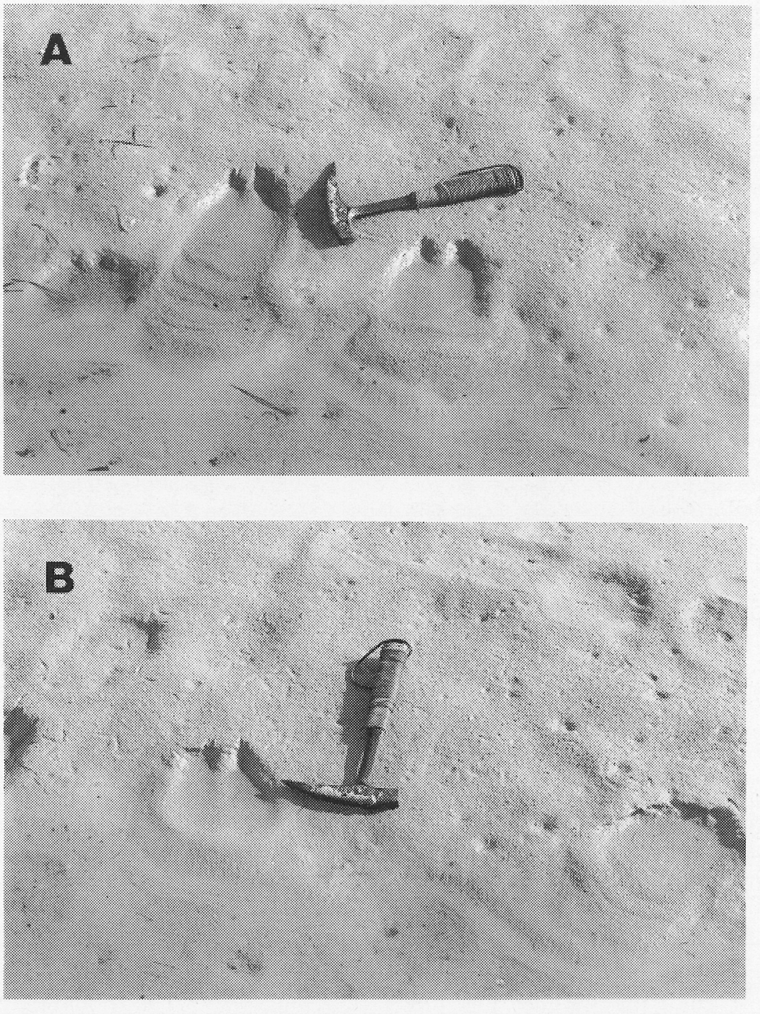

Figure 2 Typical W-shaped impressions near bank-edge of creek and immediately above low tide level. Note the transition into low transverse ('meniscus') ridges with liquified sand cascading into the creek (b, bottom) and erosional degrading remnants of impressions (a, lower right; b, lower left) and trails (a and b, upper centre right); (length of hammer handle 32cm).

times >3 m, often more or less parallel to the creek bank (Figs. 4a and b). It was characterised by curved, meniscus-like, low transverse ridges, and the side margins of the trails were generally defined by prominent sand-ridges (Figs. 3a and b). Trail geometry generally suggests movement of the projenitor was more-or-less continuous and tended to be directional rather than meandering and haphazard. Nevertheless, many of the longer trails displayed abrupt breaks or direction changes (Figs 3 and 4) indicative of hesitancy and intermittent movement patterns. In several instances there was a vague medial indentation or offset in the transverse ridges (Fig. 3b). Many of these trails terminated at and/or passed gradationally into a W-shaped impression (Fig. 3). Closely comparable traces have also been seen on tidal flats of the Mangawhai

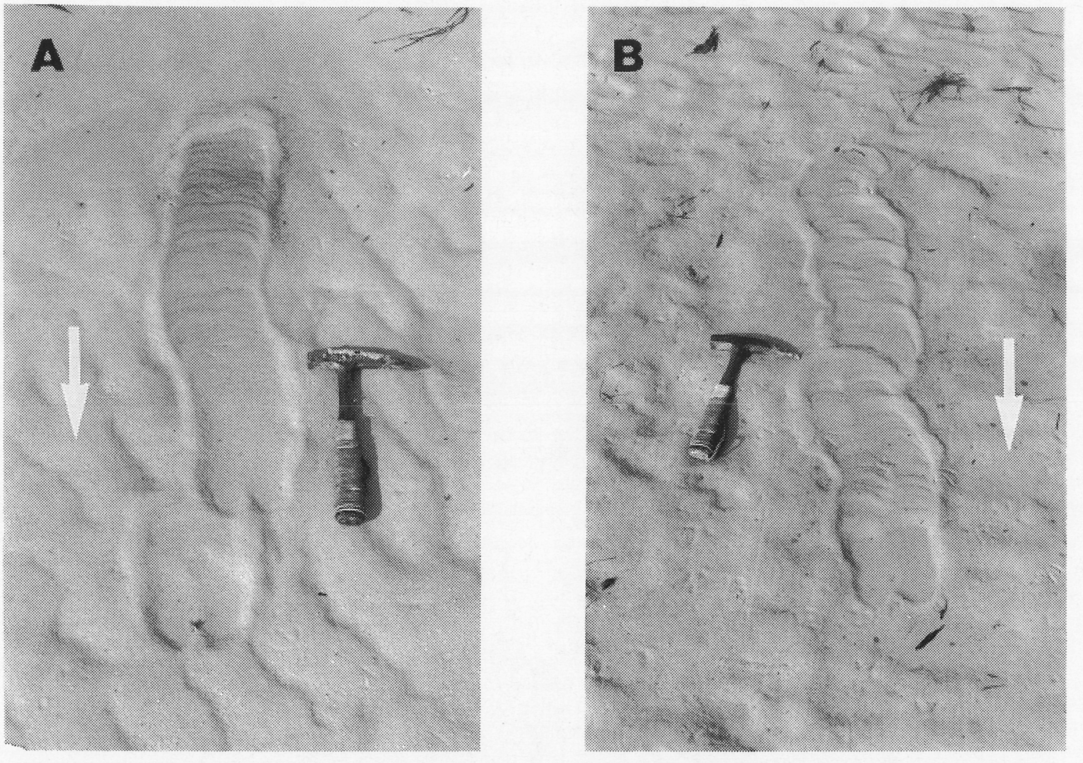

Figure 3 Simple surface trails over 1 m in length and terminating in W-shaped impressions in rippled fine sand. Note the raised margin on either side and the transverse arcuate ridges; the latter with a vague (a) to prominent (b) medial indentation and minor en echelon offsets. Also note the major break and conspicuous side-stepping in the body of the trail (lower a; centre b). Arrows indicate direction of backwards movement. (Hammer for scale).

estuary (Fig. 1) (M. Wiley, pers. comm.) where the sediments are texturally very similar to those of Rarawa (Fig. 5). Cattle had been heard thrashing through nearby scrub and wading in the estuary before first light on the morning these impressions and trails were discovered, and initially they were considered hoof prints. However, the trails were never paired and this possibility was thus excluded. There is some superficial resemblance to the enigmatic late Cambrian, large trace fossil, *Climactichnites* produced by an unknown animal, moving across well-sorted, damp (cf. intertidal) fine sand through muscular contractions that alternate from side to side (see Yochelson & Fedonkin 1993).

The Rarawa trace impressions and associated trails are virtually identical to features described and figured from the broad tidal flats of the Wadden Sea (e.g. Swennen & van der Baan 1959, p 17, Schäfer 1972, pl 5b, Ehlers, 1988, Fig. 60, Cadée 1990, Fig. 2) and Baltic Sea (Müller 1985). Here they have been made in shallow water and intertidal saturated substrates by several of the gulls common to Europe, and which are known to feed on occasions by a "foot-paddling" mechanism (Simmons 1961, Sparks 1961, Tinbergen 1962). Cadée (1990) has reported that the Black-headed gull (*Larus ridibundus*) faces into the wind when feeding this way, and as it moves backwards seizes prey items

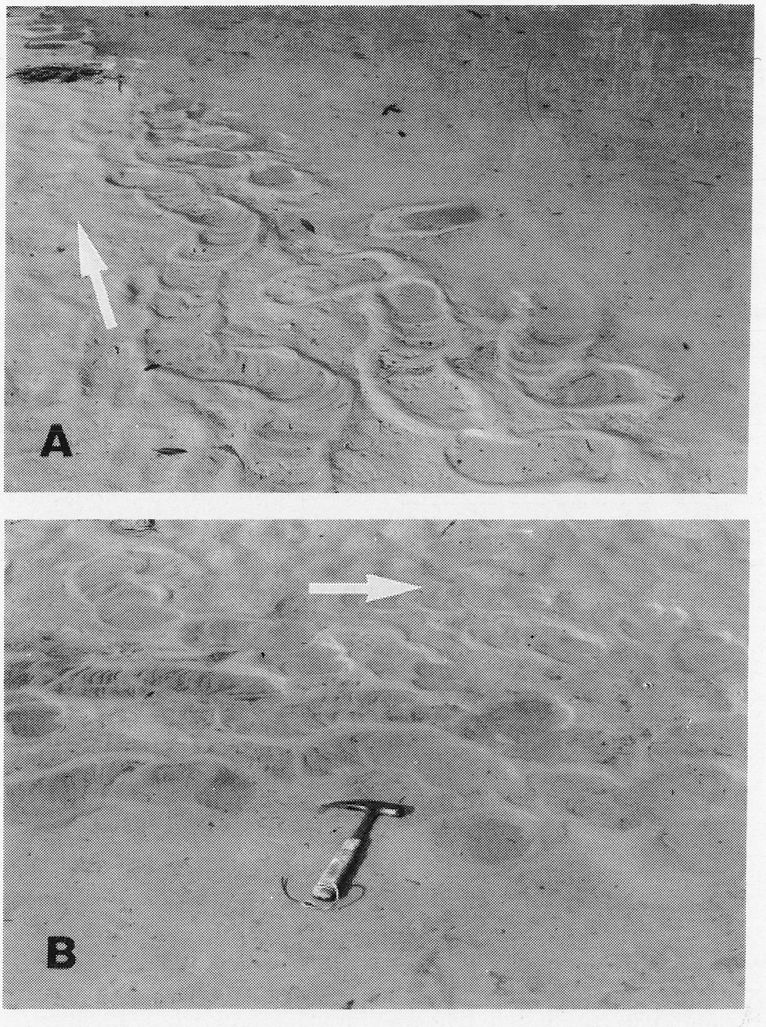

Figure 4 Intensive reworking of rippled surficial sediment by paddling trails more or less paralleling water's edge; creek bed with ponded water top right (a) and lower left (b). Note the raised lateral margins and meandering character. Arrows indicate general sense of backwards movement. (Hammer for scale).

as they rise to the surface of the momentarily fluidised sand. The foot-trembling behaviour of several plover species (Simmons 1961) may be responsible for similar feeding trails but this has not been substantiated.

Interpretation

Foot-paddling behaviour has been observed in New Zealand's Southern Black-backed gull (*Larus dominicanus*) (Fordham 1963) as well as in the smaller Red-billed and Black-billed gulls (*L. novaehollandiae scopulinus* and *L. bulleri*) (Dawson 1966). The recently arrived Black-fronted dotterel also indulges in foot-trembling (Heather 1977). Although no birds were observed in the act of making impressions or trails at Rarawa, size alone and comparisons with the feeding traces of the similarly sized Herring gull (*Larus argentus*) in Europe (e.g. Schäfer 1972, p 15b) suggests the Southern Black-backed gull was most likely responsible. Southern Black-

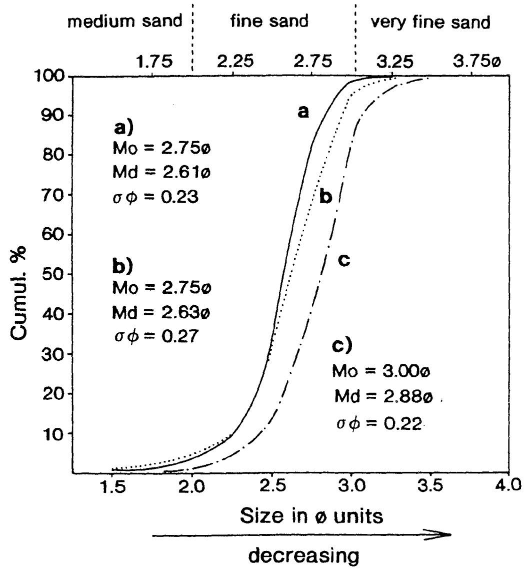

Figure 5 Well-sorted fine sands typify the intertidal substrates in which the *Larus* feeding trails have been seen: Rarawa (a) and Mangawhai (b) Estuaries, and Bridgewater Beach, Australia (c).

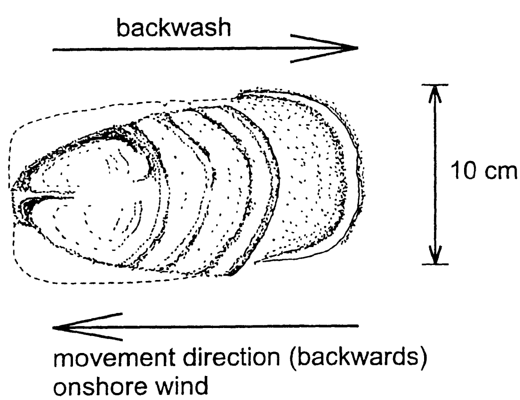

Figure 6 Simplified line drawing of ephemeral marking left between successive swash episodes by a foot-paddling Silver gull - Bridgewater Beach, Victoria, Australia. Dashed line indicates probable original outline of trace prior to degradation through backwash erosion (Based on field sketch).

backed and Red-billed gulls were present in and around the estuary and along the adjacent beach of Great Exhibition Bay at the time. Several individuals of the former were noted briefly foot paddling in pools <10 cm deep during a later visit to the same locality but no trails or impressions resulted although there was obliteration of surface ripple marks over an area of some 15×15 cm^2. In the very low gradient swash zone of a high energy, hard-packed fine sandy beach at Bridgewater, near Portland, Victoria, Australia, I watched a local Silver gull (*Larus novaehollandiae*) foot-paddling in water <2 cm deep. After the backwash receded, a broad degrading ovoidal depression with several indistinct and incomplete arcuate ridges in front of it was revealed (Fig. 6). The bird had been facing into an on-shore wind. The feature did not persist as a recognisable entity through the next swash/backwash episode. Both Black-backed and Red-billed gulls are also common at Mangawhai.

The fine sandy sediments at all three localities (Fig. 5) readily fluidise under gentle vibration, as was demonstrated in an experiment with surrogate legs during which vaguely comparable impressions and trails were generated. Variations in substrate penetrability between ridge crests and troughs which can influence feeding patterns of some shore birds (e.g. Grant 1984) do not appear to have been a factor in the development of these impressions and trails.

Discussion

Although the prospect for ephemeral traces of this kind being preserved in the geological record seems unlikely, experience with feeding holes of local eagle rays indicates it is not impossible (Gregory 1991a). However, there is evidence that the Southern Black-backed Gull is only recently present in large numbers along New Zealand shores (Chambers 1989), so while spectacular exposures of fossil avian feeding trackways or tramplings similar to those of some dinosaurs (see Lockley 1991) are not to be expected here, they could occur elsewhere.

Foot tapping, trembling, shaking or puddling behaviour, similar to the paddling of *Larus* spp., has been widely reported amongst New Zealand plovers and dotterels (e.g. Serventy *et al.* 1971, Heather 1977, Phillips 1977, Pierce 1980, Searle 1984, Tarburton 1989, Marchant & Higgins 1993). With large numbers of resident, migrant and vagrant representatives of these and other shorebird taxa (e.g. oyster catchers, stilts, knots) congregating on the intertidal mud- and sandflats of the Firth of Thames and Manukau Harbour (see Veitch 1978) considerable churning over (avian bioturbation) of surficial sediment will occur (see Thrush *et al.* 1994). The *Larus* trails at Rarawa had often brought to the surface and spread around, dark-coloured sediment from beneath the redox boundary. Herein may lie a factor warranting further thought when attention is being given to the impact of contaminants and the possibility of their release and transport from, or transfer within, soft intertidal and wetland substrates of the kinds typical of many New Zealand harbours and estuaries. The importance of bioturbation in effecting contaminant release from subtidal seabed sediments has already been acknowledged (e.g. Bosworth & Thibodeaux 1990, Gregory 1991b).

Trails of this kind in the littoral zone of the Baltic Sea have been considered *Rhizocorallium*-like (Müller 1985). Assignment to this well-known ichnogenus is erroneous. It consists of a simple (paired) U-tube with spriete between. The tubes are parallel and typically somewhat oblique to bedding after being initially vertical. Outer surfaces of the tubes often display stria or striae taken to be the scratchings of crustacean projenitors (Häntzchel 1975). The tubes of *Rhizocorallium* are typically circular in cross section, of uniform diameter and sharply demarcated on texture (and sometimes colour) from the hosting sediment. The bounding outer ridges of *Larus* trails tend to be irregular, are not circular in cross-section, and have little potential to be preserved as tubes. Furthermore, few *Rhizocorallium* reach the size of *Larus* trails.

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